

MN Dra - In-the-Gap Dwarf Nova With Negative Superhumps

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Abstract. The multi-site photometric observations of MN Dra were made over 77 nights in August-November, 2009. The total exposure was 433 hours. During this time the binary underwent two superoutbursts and five normal outbursts. During the course of first superoutburst period of positive superhumps decreased with extremely large $\dot{P} = -1.5 \times 10^{-4}$ for SU UMa-like dwarf novae, confirming known behavior of MN Dra [1]. Between the superoutbursts MN Dra displayed negative superhumps. Their period changed cyclically around 0.096-day value.

Keywords: MN Dra; negative superhumps; normal outbursts

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INTRODUCTION

MN Dra is an SU UMa-type dwarf nova in the period gap [2] with a short supercycle of ~ 60 day [3]. During the superoutbursts it displays the positive 0.105-day superhumps [3]. The period of superhumps decreases with a \dot{P} of an order of 10^{-4} , extremely large for SU UMa-type dwarf novae [1]. In 2009 after the end of the May superoutburst we first found the large-amplitude brightness variations existing both in quiescence and during normal outbursts [4]. These variations have period 0.096 day and sometimes reach the amplitude of $1^m.4$ when the object is in low quiescence. Although the orbital period is still unknown, we interpreted that these variations are negative superhumps caused by the nodal precession of a tilted accretion disk. In order to study the behavior of the 0.096-day variations we undertook a new campaign in 2009 that covered almost two consecutive supercycles.

OBSERVATIONS

The CCD photometrical observations of MN Dra were carried out in the Crimean astrophysical observatory with the Shajn 2.6-m mirror and the 38-cm Cassegrain telescopes,

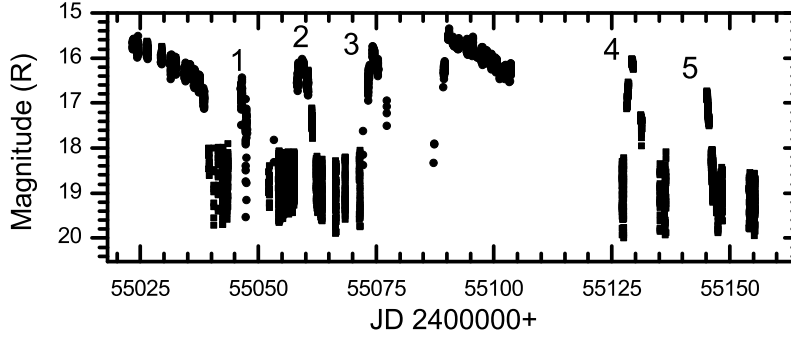


FIGURE 1. Light curve of MN Dra over two supercycles

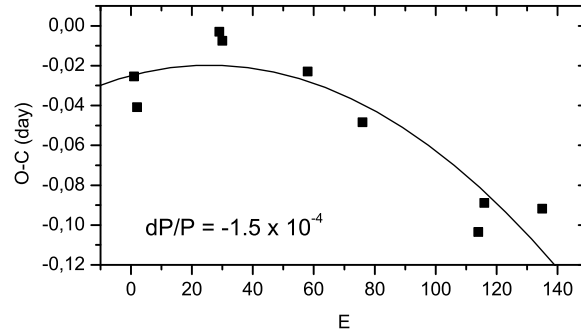


FIGURE 2. $(O - C)'$ s of the positive superhump maxima for the first superoutburst

in the Crimean laboratory of the Sternberg astronomical institute with the 60-cm Zeiss telescope, in the Tatranska Lomnica observatory with the 50-cm telescope and in the Terskol observatory with the 60-cm telescope. The multi-site observations were made over 77 nights (433 hours) in August-November and covered two superoutbursts and five normal outbursts. The observations were performed in R band or in white light. In the later case the data were reduced to R . The overall light curve is shown in Fig.1.

SUPEROUTBURSTS

During both superoutbursts MN Dra showed the positive superhumps. Their period decreased with time. In Fig. 2 the evolution of the superhump period for the first superoutburst is shown. The $(O - C)'$ s were calculated for the superhump maxima accordingly the ephemeris

$$HJD_{max} = 2455023.28 + 0.105416 \times E \quad (1)$$

It is seen that period of positive superhumps decreases with $\dot{P} = -1.5 \times 10^{-4}$ during 135 cycles. That confirms the extreme value of \dot{P} for the previous superoutbursts of MN Dra -1.0×10^{-4} [1]. Nogami et al. [3] measured an even more extreme value of $\dot{P} = -17 \times 10^{-4}$.

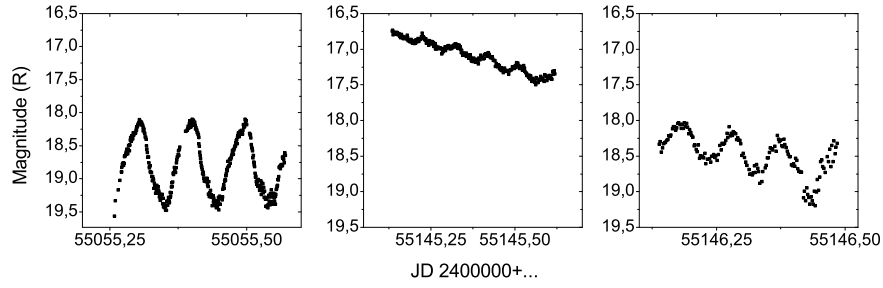


FIGURE 3. Examples of original light curves containing the negative superhumps for the quiescent state (left), leaving the top of a normal outburst (middle) and approaching to quiescence (right)

EVOLUTION OF NEGATIVE SUPERHUMPS

Outside the superoutburst there are the brightness variations in minimum and normal outbursts interpreted that these variations are the negative superhumps. As was shown earlier (Pavlenko et al., 2010), the amplitude of superhumps varied from $0^m.1 - 0^m.2$ in the outburst maximum to $1^m - 1^m.4$ in minimum. The examples of the light curves in minimum, start and end of the outburst decline are shown in Fig. 3. They show a growth of amplitude when brightness decreases. In a scale of intensities the amplitudes of all the data are situated within the same strip. It is worth noting that the data in minimum that are well separated from the normal outbursts display the dependence on the mean intensity (see Fig. 4). The times of maxima were determined for the negative superhumps. We used a period of 0.09598 day for calculating of the $(O - C)'$ s. The $(O - C)'$ s during the supercycle display a cyclic change. In Fig. 5 the $(O - C)'$ s variations are presented together with light curves of normal outbursts. One could see that superhump period varies cyclically between normal outbursts around 0.096-day period, being the longest at the end of quiescent state preceding the normal outburst. These variations look like a jump-like switching of the period of negative superhumps from the longest value to the shortest one during the beginning of a normal outburst. Then the period of negative superhumps smoothly increases to its previous value.

CONCLUSION

We first established the cycling change of the $(O - C)'$ s of negative superhumps and the dependence of amplitudes of negative superhumps on mean intensity of the system. More data (both spectroscopic and photometric) are needed to determine the orbital period of MN Dra and to understand how the outbursts impact on the nodal precession.

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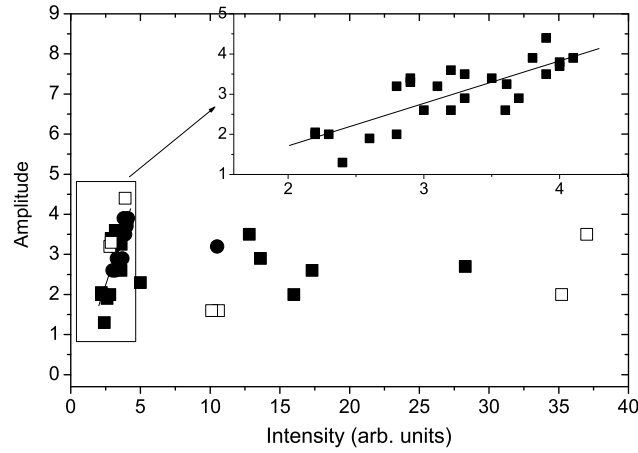


FIGURE 4. Dependence of the negative superhumps amplitude on the mean intensity in minimum. Dependence of amplitude on the mean intensity for the data in quiescence is given in detail in the breakout. The data obtained with ZTSh are designed by filled circles, with 60-cm (Terskol) - by filled squares and with 60-cm (SAI) - by open squares

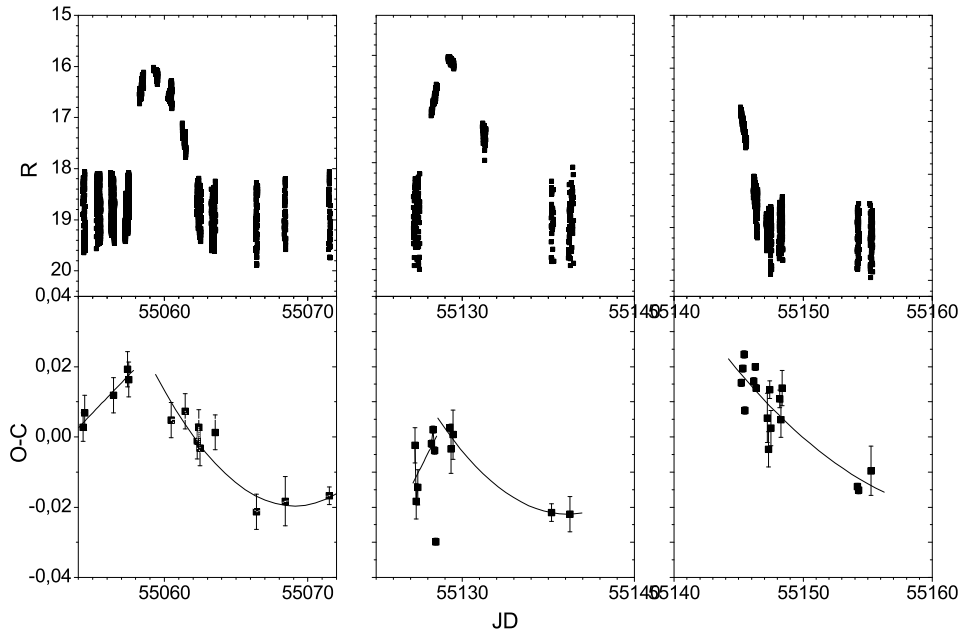


FIGURE 5. The behavior of the $(O - C)'$ of negative superhumps (lower part of figure) for three normal outbursts (upper part of figure)

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